CLAIMS:

What is claimed is:

1. A method for optimizing operation of a refrigeration system having an evaporator, comprising:

defining an inner control loop for optimizing a supply of liquid refrigerant to the evaporator; and

defining an outer control loop for optimizing a level of refrigerant in the evaporator,

said outer control loop defining a supply rate for said inner control loop based on an optimization including measurement of evaporator performance,

said inner control loop optimizing liquid refrigerant supply based on said defined supply rate.

2. The method according to claim 1, further comprising the step of predicting a need for refrigeration system service.

3. The method according to claim 1, further comprising the step of providing a buffer for supply of refrigerant to the evaporator, the level of the buffer being responsive to said outer control loop.

4. The method according to claim 1, further comprising the step of estimating an oil migration into the evaporator.

5. The method according to claim 1, wherein said outer control loop is adaptive.

6. The method according to claim 1, wherein said inner control loop comprises a feed-forward characteristic.

7. The method according to claim 1, wherein said outer control loop compensates for oil migration into the evaporator.

8. The method according to claim 1, wherein the outer control loop compensates for alteration in refrigerant charge condition.

9. The method according to claim 1, wherein at least one of the inner control loop and the outer control loop perform a cost-optimization.

10. The method according to claim 1, wherein at least one of the inner control loop and the outer control loop perform a cost-optimization of a process, said cost-optimization encompassing the refrigeration system and at least one component of a plant employing the refrigeration system.

11. The method according to claim 1, further comprising the step of modifying evaporator performance by separating oil from refrigerant in the refrigeration system.

12. The method according to claim 1, further comprising the step of providing an adaptive model of the refrigeration system for predicting a response of the system to changes in a process variable.

13. A refrigeration system comprising a compressor for compressing a refrigerant, a condenser for condensing refrigerant to a liquid, and an evaporator for evaporating liquid refrigerant from the condenser to a gas, and a controller which optimally controls both a supply of liquid refrigerant to the evaporator and a level of refrigerant in the evaporator.

14. The refrigeration system according to claim 13, wherein the controller uses a genetic algorithm to predict an optimal state.

15. The refrigeration system according to claim 13, wherein said controller comprises:

an inner control loop for optimizing a supply of liquid refrigerant to the evaporator; and

an outer control loop for optimizing a level of refrigerant in the evaporator,

said outer control loop defining a supply rate for said inner control loop based on an optimization including measurement of evaporator performance,

said inner control loop optimizing liquid refrigerant supply based on said defined supply rate.

16. The system according to claim 15, further comprising a buffer for storing a reserve of liquid refrigerant.

17. The system according to claim 16, wherein a level of reserve liquid refrigerant is controlled by said outer loop.

18. An apparatus, comprising:

an input for receiving physical parameters useful for a thermodynamic analysis of refrigeration system performance;

a processor for performing a thermodynamic analysis of the refrigeration system and determining consistency of the thermodynamic analysis; and

an output for presenting an estimate of deviance from an optimal state of the refrigeration system based on said thermodynamic analysis and said consistency analysis.

19. The apparatus according to claim 18, wherein said processor estimates a refrigeration efficiency of the refrigeration system in an operational state, further comprising means for altering a process variable of the refrigeration system during efficiency measurement and calculating a process variable level which achieves an optimum efficiency.

20. The apparatus according to claim 18, further comprising a control for altering physical parameters by altering at least one of an oil concentration in an evaporator and a refrigerant charge of said refrigeration system.

21. A method for determining a deviance from optimum of a refrigeration system, comprising:

obtaining physical parameters for a thermodynamic analysis of refrigeration system performance;

performing a thermodynamic analysis of the refrigeration system;

determining consistency of the thermodynamic analysis with a model of the refrigeration system; and

outputting an estimate of deviance from an optimal state of the refrigeration system based on said thermodynamic analysis and said consistency analysis.

22. The method according to claim 21, wherein said estimate of deviance is used to determine a need for refrigeration system service.

23. The method according to claim 21, wherein said estimate of deviance is used to estimate a refrigeration system capacity.

24. The method according to claim 21, wherein said thermodynamic analysis relates to a state of the refrigeration system, further comprising the step of monitoring refrigeration system performance in real time over a range of operating conditions to determine operating-condition sensitive physical parameters.

25. The method according to claim 21,

wherein said thermodynamic analysis comprises estimating an efficiency of the operating refrigeration system;

further comprising the steps of:

altering a process variable of the refrigeration system;

calculating a refrigeration system characteristic based on an analysis of obtained physical parameters after said alteration; and

optimizing a process variable level in accordance with the determined system characteristic.

26. The method according to claim 25, wherein the process variable is compressor oil dissolved in the refrigerant in the evaporator.

27. The method according to claim 25, wherein the process variable is refrigerant charge condition.

28. The method according to claim 25, wherein an optimum efficiency is determined based on surrogate process variables.

29. The method according to claim 25, wherein the operating point is maintained by closed loop control based on the determined optimum efficiency process variable level.

30. The method according to claim 25, wherein the process variable is compressor oil dissolved in the refrigerant in the evaporator, and wherein the process variable is altered by separating oil from refrigerant in the refrigeration system.

31. The method according to claim 21, further comprising the step of predicting a cost-benefit of a service operation on said refrigeration system to correct at least a portion of the deviance from said optimal state.

32. The method according to claim 21, further comprising the steps of:

determining a sensitivity of the refrigeration system to perturbations of at least one operational parameter;

defining an efficient operating regime for the refrigeration system based on the determined sensitivity; and

performing a service of the refrigeration system to bring the at least one operational parameter within the efficient operating regime when the refrigeration system is operating outside the defined efficient operating regime and a correction thereof is predicted to be cost-efficient.

33. The method according to claim 32, wherein the operating regime has a non-trivial double ended range of values, and continued operation of the refrigeration system follows a consistent trend in change in operating point from a beginning of cycle operating point to an end of cycle operating point, wherein the service alters the at least one operational parameter to within a boundary of the non-trivial double ended range of values near the beginning of cycle operating point.

34. The method according to claim 32, wherein the operational parameter is oil concentration of refrigerant in the evaporator.

35. The method according to claim 32, wherein the service comprises a purification of the refrigerant.

36. The method according to claim 32, wherein the at least one operational parameter is estimated by measuring an energy efficiency of the refrigeration system.

37. The method according to claim 21, further comprising the step of predicting a refrigeration capacity of the refrigeration system.

38. The method according to claim 21, further comprising the steps of:

defining cost parameters of operation of the refrigeration system;

determining usage parameters of the refrigeration system;

predicting a thermodynamic effect of a service procedure on a machine with respect to efficiency;

estimating a cost of the service procedure; and

conducting a cost benefit analysis based on the operation cost parameters, usage parameters, predicted thermodynamic effect and estimated cost.

39. A method, comprising the steps of:

thermodynamically modeling a refrigeration system with respect to at least refrigerant purity and superheat level;

predicting a thermodynamic effect of an alteration of a refrigerant purity and compressor power;

altering at a refrigerant purity and a compressor power to achieve a predicted optimum condition under operating conditions.

40. The method according to claim 39, wherein compressor power is modulated by at least one of speed control, duty cycle control, compression ratio, and refrigerant flow restriction.

41. The method according to claim 39, wherein refrigerant purity is altered by changing a level of non-condensible gasses therein.

42. The method according to claim 39, wherein the predicting step comprises using a genetic algorithm.